CAREER: Time-Resolved Studies of Correlated Electronic Materials I
Jay Kikkawa, U. of Pennsylvania, DMR-0094156

Our studies probe unusual connections between magnetism and electrical current flow that arise in certain classes of magnetic oxides. Progress in this area could lead to materials wherein electrostatic forces control magnetic responses. Our approach involves using ultra-short laser pulses to disturb the electronic and magnetic state of the system, and subsequently measuring how the system returns to equilibrium.

Highlights of this work include:

(1) A discovery that the method of inferring spin dynamics via reflectivity, used widely throughout the literature, can give incorrect results. (Figure 2)

(2) Nucleation of transient conducting, ferromagnetic bubbles from the high-resistance state. (Figure 3)

Figure 1: A helpful exercise is to visualize pump-induced changes in a magnetic oxide as excursions in the system's phase diagram. To the right we show the coupled electrical and magnetic transitions in the oxide $Pr_{0.7}Ca_{0.3}MnO_3$ at T=35 K.

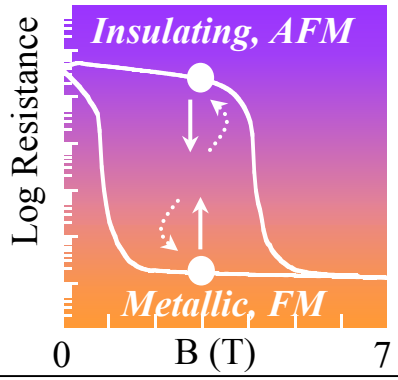
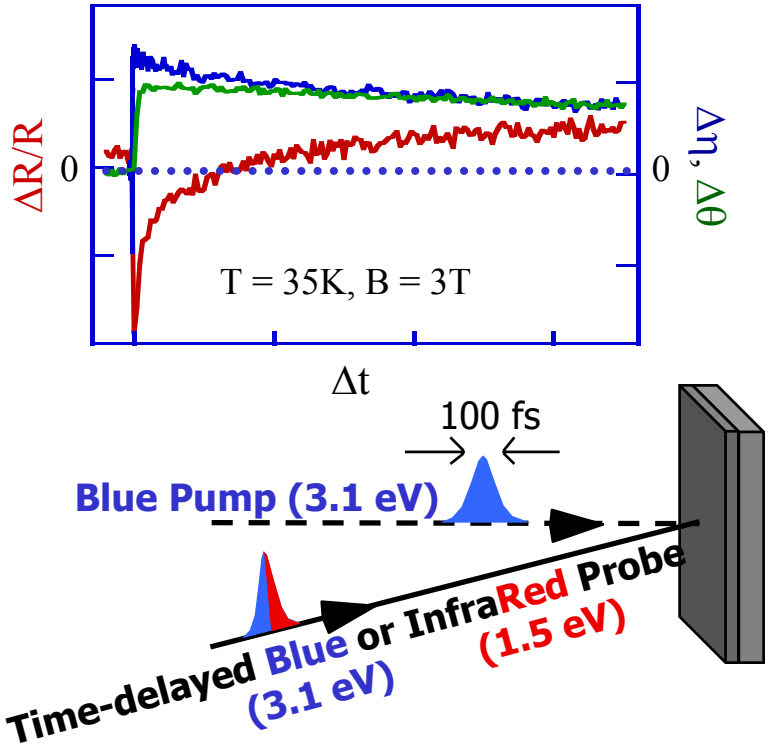


Figure 2: The transient reflectivity, ΔR/R, is commonly used as a measure of spin dynamics in the manganites. Our simultaneous measurements of the Kerr effect, however, directly record magnetic transients exhibiting a different behavior.



CAREER: Time-Resolved Studies of Correlated Electronic Materials II
Jay Kikkawa, U. of Pennsylvania, DMR Award#0094156

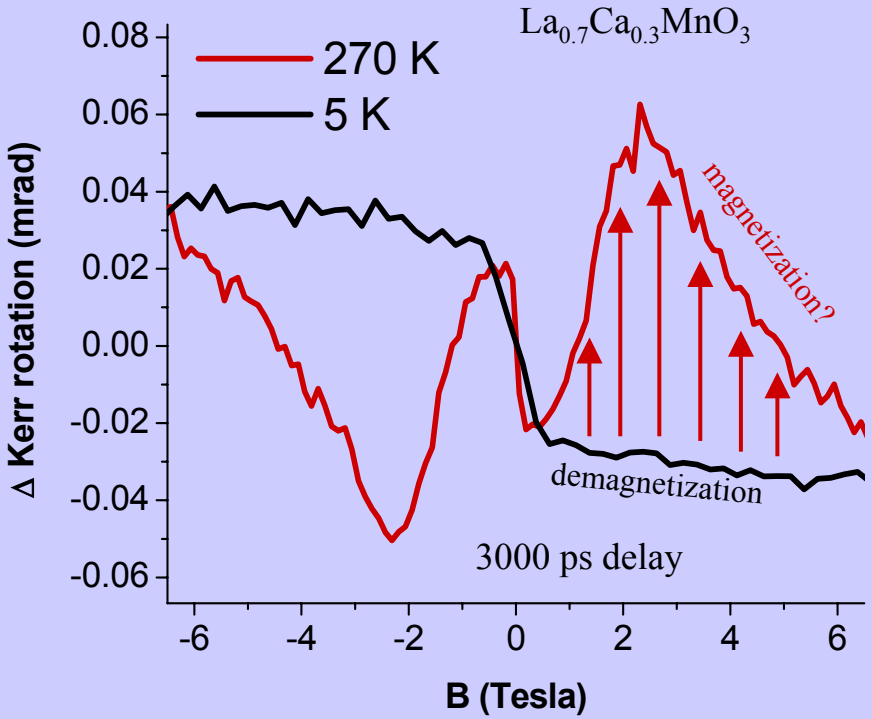


Figure 3 – This snapshot of magnetic dynamics suggests an *increase* in magnetization caused by a short optical pulse in the magnetic oxide $La_{0.7}Ca_{0.3}MnO_3$. The change is transient, disappearing within 1 millisecond. Even though this material does exhibit spontaneous ferromagnetism, the magneto-optical couplings we observe in our time-resolved measurements appear exclusive to the non-equilibrium state. These findings suggest that optical excitation creates an entirely new phase that does not occur within the material's ground state phase diagram.

Educational:

1 undergrad: Felix Mendoza (now at UCSB)

2 grad students: Stephen McGill, Omar Torrens

Synopsis of Outreach activities:

The PI is developing robotically-controlled remote physics demonstrations for high school students. High school students will be able to grab the controls of an apparatus within the PI's lab and perform experiments. This year in collaboration with Harriet Slogoff, an educator at Penn, we developed a workable idea for this project that will involve construction of a Rube Goldberg apparatus in which each step has a parameter that a student can vary (temperature of a metal springboard, angle of a ramp, compression of a spring, etc). Students will be challenged to obtain the correct parameters to make the system complete its motion. Each variable adjusted by the student will provide an opportunity for a discussion of the relevant physics.